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Sources, Ratios and Mixtures of Organic and Inorganic Nitrogen Influence Plant Height of Hybrid Rice (*Oryza sativa*) at Various Growth Stages

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Abstract

In rice-wheat cropping system of Pakistan the inorganic nitrogen (N) fertilizers represent the largest component of the N cycle because the N supply from soil organic matter is inadequate. The required inorganic N fertilizer may be reduced with the use of different organic sources (OS) especially animal manures (AM) and crop residues (CR). Field experiment was conducted to assess the impact of different OS applied alone and in various combinations with inorganic-N [urea (U)]on the plant height at different growth stages of rice hybrid (*Oryza sativa* L., Pukhraj) under rice-wheat cropping system in northwestern Pakistan. The experiment was conducted on farmer field at Batkhela (Malakand) during two consecutive years 2011-12 and 2012-13. The results revealed that plant height was higher with application of sole urea > combined application of urea + OS > pure OS > control (N not applied). Among the six OS used [three animal (poultry, sheep and cattle manures) and three crop residues (onion, berseem and wheat)], application of poultry manure (PM) produced taller plants, while shortest plants were recorded with application of wheat residues (WR) at different growth stages (tillering, flowering and physiological maturity). Application of animal manures (AM) were better in terms of taller plants produced than the crop residues (CR). Application of the required N (120 kg N ha^{-1}) in the ratio of 75U: 25OS (75 % N was applied from urea and 25 % N was applied from organic source) produced taller plants, while the ratio 25U: 75OS (25 % N was applied from urea and 75 % N was applied from organic source) produced dwarf plants. Among the various mixtures, combined application of U + PM produced taller plants, while the shortest plant height was obtained with U + WR. The planned mean comparison indicated that the rest (N treated plots) produced taller plants than control at three different growth stages of rice. The increase in plant height with nitrogen application had positive impact on the total rice biomass in the study area.

Keywords: *Rice; Oryza sativa L; Organic; Inorganic; Nitrogen; Ratios; Plant height; Growth stages*

Introduction

Rice-wheat rotations are the most important cropping system in southern and eastern Asia, covering an estimated area of 21.9 million ha in seven countries: Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan [1]. In rice-wheat cropping system of Pakistan the inorganic nitrogen (N) fertilizers represent the largest component of the N cycle because the N supply from soil organic matter is inadequate. The continuous use of chemical fertilizers without organic sources would lead gradual decline of organic matter content and native N status in the soil, which results in lower rice production. From the sustainability points of view, alternatives have to be found out to improve the productive capacity of rice soils. Earlier Research work revealed that judicious and proper use of fertilizers can improve growth, increase yield and rice quality [2]. The type of N fertilizer may also affect the growth, yield and grain quality [3]. Some of these fertilizers are substantially cheaper than others, and their use may be more economical grounds provided they do not adversely affect the growth, yield and grain quality [3]. In the face of continuing global energy crisis and progressively prohibitive cost of fertilizer N, there is a renewed interest towards sustainable low cost alternatives like organic manures. So there is a need to explore an alternative system nutrient supply. Among various organic manures are considered as the promising renewable, nutrient rich source and can be served as

a substitute to cut down the costs of fertilizers input [4]. For the efficient management of N in the cropping systems, adequate rate, appropriate source and timing of application during crop growth cycle play an important role [5]. Inorganic, organic and bio-fertilizers are the main sources for replenishing plant nutrients in agricultural soils [6]. The ever increasing prices of chemical N-fertilizers and due to the concern of environmental pollution arising from their application, have renewed interest in integrated plant nutrition, especially in the use of organic N-fertilizers especially animal manures and crop residues for improving growth and productivity in rice based system. Hence, it is necessary to find out the extent and possibility of substituting fertilizer N with less costly and more effective sources for sustainability and yield stability. Because soil organic sources provides not only the nutrients to the soil, but also improves water holding capacity and helps the soil to maintain better aeration for seed germination and plant root development [7]. Therefore, the combined use of organic fertilizers along with chemical fertilizers may be utilized as an effective tool to improve growth and increase yields [8]. The present study was, therefore, selected to investigate the interactive effect of organic into inorganic N-fertilizers for improvement in rice growth and yield.

Materials and Methods

A field experiment was conducted to investigate the impact of organic and inorganic N-fertilizer on growth (plant height) of rice under rice-wheat system at Batkhela Malakand Agency, Northwest Pakistan during 2011-12 and 2012-13. Batkhela is located at 34°37'0" N and 71°58'17" E in DMS (Degrees Minutes Seconds) or 34.6167 and 71.9714 (in decimal degrees). The soil of the experimental site was clay loam, slightly alkaline in reaction (pH = 7.3), non-saline (ECe = 1.02 dS m^{-1}), moderately calcareous in nature (CaCO3 = 7.18 %), low in soil fertility containing less organic matter (0.71 %), total N (0.51%), extractable P (5.24 mg kg^{-1}) and Zn (0.93 mg kg^{-1}). The detail 26 treatments combination while using various sources and ratios of organic and inorganic N-fertilizers is given in Table 1. Organic sources [three animal manures viz. poultry manure (PM), sheep manure (SM) and cattle manure (CM), and three crop residues viz. wheat residues (WR), berseem residues (BR) and onion residues (OR)] were applied 30 days before transplanting, while the required urea was applied in two equal splits i.e. 50% each at transplanting and 30 days after transplanting. A uniform basal dose of 60 kg P_2O_5 ha^{-1} as triple super phosphate (TSP) and 60 kg K_2O ha^{-1} as sulphate of potash (SOP) was applied to all treatments. Nitrogen was not applied to control plots in both years. After harvest of rice crop in October, wheat was grown in November in both years as subsequent crop in both years.

The experiment was carried out in simple randomized complete block design having four replications. A plot size of $12m^2$ (3m x 4m) having 300 single plants per plot, and plant to plant distance of 20 cm apart was used. All plots were separated by 30 cm ridges to stop movement of water/nutrient among different treatments, and water to each treatment (plot) was applied separately from water channel. Data was recorded on plant height at three different growth stages i.e. at tillering, flowering and physiological maturity. Plant height at each growth stage was measured from base to top of 10 selected tillers per treatment and then average plant height was calculated.

Statistical Analysis

Data on plant height at each growth stage were subjected to analysis of variance (ANOVA) according to the methods described for randomized complete block design with split plot arrangement combined over the years, and means between treatments were compared using LSD (least significant difference) test ($p \leq 0.05$).

Results

Plant Height at Tillering

Organic sources (OS) had significant effect on plant height (PH) on average of the two years data, while in year one, year two and interaction (Y x OS) had no significant effect on PH of rice at tillering (Table 2). The average of two years data indicated that application of PM produced the highest PH (42 cm), followed by sheep manure (SM) having 41 cm height, while the lowest PH (35 cm) was recorded with application of WR. Although, PH showed non-significant response to year one and year two, yet rice produced taller plants in year two than year one. In year one, the PH ranged from 33-40 cm, while in year two, it ranged from 37-44 cm, resulted in non-significant Y x OS interaction. The ratios (R) in year one and interaction of years into ratios (Y x R) had significant effect while year two and average of two years had no significant effect on PH of rice (Table 2). The average of two years data indicated that application of N in the ratios of

75U: 25OS (75% N was applied from urea and 25% N was applied from organic source) and 50U: 50OS (50% N was applied from urea and 50% N was applied from organic source) produced the taller PH (47 cm) and 25U: 75OS (25% N was applied from urea and 75% N was applied from organic source) ratio had produced shorter plants (46 cm). The Y x R indicated that in year one, the PH was taller while using 75U: 25OS, but in year two, the ratio of 50U: 50OS produced the taller PH. The mixtures in year one and year two had significant effect on PH, while average of two years and years into mixtures (Y x Mix) interaction had non-significant effect on PH of rice (Table 2). The average of two years data indicated that application of N in the form of urea plus animal manures (U + AM) had produced the taller plants than urea plus crop residues (U + CR). The planned mean comparison indicated that the rest (N treated plots) produced taller plants (45.8 cm) than control (36.4 cm). The PH increased by 5 percent in the rest plots in year two over year one, in contrast, in the control plots, the PH decreased by 11 percent in year two over year one that resulted in significant year x control vs. rest interaction. Application of sole urea produced taller plants (52.1 cm) than mixtures (45.8 cm). The PH increased by one percent in the sole urea plots in year two than year one, but in contrast, the PH increased by 1.6 percent in year two over year one in the mix plots that resulted in non-significant year x U vs. Mix interaction. Application of mixtures produced taller plants (46.6 cm) than pure OS (39.2 cm). The increase in PH was 9 percent in year two over year one while using pure OS, but application of N in the form of mixtures increased PH by five percent in year two over year one that resulted in non-significant Y x OS vs. mix interaction. The PH was higher with sole urea (52.1 cm) than pure OS (39.2 cm). The PH increased by nine percent in year two over year one while using pure OS, while in case of sole urea, the PH increased in year two by one percent than year one resulting in significant Y x U vs. OS interaction. The PH was higher with AM (45.9 cm) than CR (43.6 cm) but the differences was non-significant. The PH increased by six percent in AM and 7 percent in CR which resulted in non-significant Y x AM vs. CR interaction. The PH increased with application of sole urea (104 cm) than pure OS + mixtures (94 cm). The PH increased by six percent in year two over year one while with pure OS + mix, while in case of sole urea, the PH increased by one percent in year two than year one resulting in non-significant Y x U vs. pure OS + mix interaction.

Plant Height at Flowering

Organic sources (OS) had significant effect on plant height (PH) in year one and average of the two years data, while year two and interaction (Y x OS) had no significant effect on PH of rice (Table 3). The average of two years data indicated that application of PM produced the highest PH (85 cm), followed by 82 cm noted for cattle manure (CM), while the lowest PH (71 cm) was recorded with application of WR. Although, PH showed significant response to year one while having no significant response to year two, yet rice produced taller plants in year two than year one. In year one, the PH ranged from 67-78 cm, while in year two, it ranged from 75-88 cm. The PH increased by 11 % in year two over year one while using BR but the increase was just six percent in year two over year while using SM that resulted in non-significant Y x OS interaction. The ratios in year one, year two and interaction of Y x R had significant effect while average of two years had no significant effect on PH of rice (Table 3). The average of two years data indicated that application of N in the ratio of 50U: 50OS produced the taller PH (95 cm) and 25U: 75OS ratio had produced dwarf plants (92 cm). The Y x R indicated that in year one, the PH was taller while using 75U: 25OS, but in year two, the ratio of 50U: 50OS produced the taller PH. The PH increased by 9% each in year two over year one with 50U: 50OS and 25U: 75OS, on the other hand the PH decreased by three percent in year two over year one while using 75U: 25OS that resulted in significant Y x R interaction. The mixtures in year one had significant effect on PH, but year two, average of two years and Y x Mix interaction had non-significant effect on PH of rice (Table 3). The average of two years data indicated that application of N in form of U + PM produced the taller PH (98 cm), while the lowest PH was obtained with U + WR (89 cm). The increase in PH in year two over year one ranged between four to six percent in all mixtures resulting in non-significant Y x Mix interaction. The planned mean comparison indicated that the rest (N treated plots) produced taller plants (92 cm) than control (72 cm). The PH increased by five percent in the rest plots in year two over year one, in contrast, in the control plots, the PH decreased by eight percent in year two over year one that resulted in significant year x control vs. rest interaction. Application of sole urea produced taller plants (104 cm) than mixtures (92 cm). The PH increased by two percent in the sole urea plots in year two than year one, but in contrast, the PH increased by just one percent in year two over year one in the mix plots that resulted in non-significant year x U vs. Mix interaction. Application of mixtures produced taller plants (94 cm) than pure OS (79 cm). The increase in PH was nine percent in year two over year one while using pure OS, but application of N in the form of mixtures increased PH by five percent in year two over year

one that resulted in non-significant Y x OS vs. mix interaction. The PH was higher with sole urea (104 cm) than pure OS (79 cm). The PH increased by nine percent in year two over year one while using pure OS, while in case of sole urea, the PH decreased in year two by two percent than year one resulting in significant Y x U vs. OS interaction. The PH was higher with AM (92 cm) than CR (87 cm) but the differences was non-significant. The PH increased by six percent each in year two over year one while using either AM or CR which resulted in non-significant Y x AM vs. CR interaction. The PH increased with application of sole urea (104 cm) than pure OS + mixtures (94 cm). The PH increased by five percent in year two over year one while with pure OS + mix, while in case of sole urea, the PH increased by two percent in year two than year one resulting in non-significant Y x U vs. pure OS + mix interaction.

Plant Height at Physiological Maturity

Organic sources (OS) had significant effect on plant height at maturity (PHM) in year one and average of the two years data, while year two and interaction (Y x OS) had no significant effect on PHM of rice (Table 4). The average of two years data indicated that application of PM produced the highest PHM (92 cm), while the lowest PHM (77 cm) was recorded with application of WR. Although, PHM showed significant response to year one while having no significant response to year two, yet rice produced taller plants in year two than year one. In year one, the PHM ranged from 74-88 cm, while in year two, it ranged 80-95 cm. The ratios in year one and interaction of Y x R had significant effect while, year two and average of two years had non significant effect on PHM of rice (Table 4). The average of two years data indicated that application of N in the ratio of 75U: 25OS produced the taller PHM (105 cm) and 25U: 75OS ratio had produced dwarf plants (102 cm). The Y x R indicated that in year one, the PHM was taller while using 75U: 25OS, but in year two, the ratio of 50U: 50OS produced the taller. The mixtures in year one had significant effect on PHM, but year two, average of two years and Y x Mix interaction had non-significant effect on PHM of rice (Table 4). The average of two years data indicated that application of N in form of U + PM produced the taller PHM (108 cm), while the lowest PHM was obtained with U + WR (99 cm). The planned mean comparison indicated that the rest (N treated plots) produced taller plants (100.7 cm) than control (76.5 cm). The PHM increased by four percent in the rest plots in year two over year one, in contrast, in the control plots, the PHM decreased by eight percent in year two over year one that resulted in significant year x control vs. rest interaction. Application of sole urea produced taller plants (109.7 cm) than mixtures (103.7 cm). The PHM increased by three percent in the sole urea plots in year two than year one, but in contrast, the PHM increased by four percent in year two over year one in the mix plots that resulted in non-significant year x U vs. Mix interaction. Application of mixtures produced taller plants (103.7 cm) than pure OS (85.6 cm). The increase in PHM was eight percent in year two over year one while using pure OS, but application of N in the form of mixtures increased PHM by four percent in year two over year one that resulted in non-significant Y x OS vs. mix interaction. The PHM was higher with sole urea (109.7 cm) than pure OS (85.6 cm). The PHM increased by eight percent in year two over year one while using pure OS, while in case of sole urea, the PHM increased in year two by three percent than year one resulting in significant Y x U vs. OS interaction. The PHM was higher with AM (101.5 cm) than CR (96.9 cm) but the differences was non-significant. The PHM increased by four percent in AM and five percent in CR which resulted in non-significant Y x AM vs. CR interaction. The PHM increased with application of sole urea (109.7 cm) than pure OS + mixtures (99.2 cm). The PHM increased by five percent in year two over year one while with pure OS + mix, while in case of sole urea, the PHM increased by three percent in year two than year one resulting in non-significant Y x U vs. pure OS + mix interaction.

Discussion

Nitrogen is one of the most growth and yield limiting nutrient in crop production in all agro ecological regions of the world [9]. Our results demonstrated that the application of sole inorganic N or sole organic N or combination of both especially with animal manures produced the tallest plants because it provided sufficient N available for the rice plants. The increase in plant height with enhanced availability of N was due to the increase in leaf area and higher photo assimilates accumulation (data not shown). These results are supported by the findings of Mandal., *et al*. [10] who reported increase in plant height with increase in leaf area. Rupp and Hubner [11] also reported the increase availability of leaf N increase plant height. Chaturvedi [12] found that application of N fertilizers increased the plant height of rice hybrid significantly, and maximum plant height (128.6 cm) was obtained application of N source (Super Net) and the dwarf plants (110.2 cm) was recorded with application of urea. The effect of organic sources alone or in combination with urea on plant height of rice probably may be due to the increase in the uptake of macronutrients, such as nitrogen, phosphorus and sulfur, and micronutrients

like Fe, Zn, Cu and Mn [13]. The organic and mineral N sources were highly effective on the heights of rice crop due to slow decomposition [14]. The reason for maximum height obtained with application of poultry manure + mineral N combined treatment probably might be due to that the mineral N source (urea) fulfilled the N requirements of rice at early growth stages while poultry manure facilitated crop with maximum nutrients in later stages. Thus excellent vegetative growth and development resulted improvement in rice growth and produced taller plants. Nitrogen was readily available from urea and there by improved rice growth and height. On the other hand, nutrient (nitrogen) availability from organic sources was slow due to microbial action and improved physical condition of soil. According to Tisdale and Nelson [15] an adequate supply of N to the crop plants during their early growth period is very important for the initiation of leaves and florets primordia. These results are also in line with those of Shah., *et al*. [16], Iqbal., *et al*. [17], Idris., *et al*. [18], Idris and Wisal and Singh and Agarwal [19] they reported that application of mineral N alone or with organic N increased plant height significantly due to the stronger role of N in cell division; cell expansion and enlargement which ultimately affect the vegetative growth of wheat plant particularly plant height. The variation in plant height due to nutrient sources was considered to be due to variation in the availability of major nutrients [20,21]. Therefore, application of organic manures alone and in combination with chemical N-fertilizer increased the plant height [6,22]. Our results demonstrated that plant height was more at later growth stages (heading and physiological maturity) than at early growth stage (tillering). However, Fageria [23] reported that plant height increased quadratically with increasing plant age and maximum height was attained at 113 days after sowing in a Brazilian upland rice cultivar. Similarly, Fageria and Knupp [24] reported that plant height increases with the advancement of age of the plant and reached to plateau at 113 days after sowing.

Conclusion

Plant height of hybrid rice in Northwestern Pakistan was significantly influenced by organic N sources and their various ratios with inorganic N (urea). Among the six organic sources used [three animal (poultry, sheep and cattle manures) and three crop residues (onion, berseem and wheat)], application of poultry manure was found the most beneficial on plant height and other growth and yield parameters (data not shown). Application animal manures were noted to be better in terms of taller rice plants and other growth parameters and yield (data not shown) than application of crop residues. Application of the required N (120 kg N ha^{-1}) in the ratio of 75U: 25OS especially in the form urea + poultry manure resulted in taller plants and total biomass and grain yields (data not shown).

Treatments	Percent N applied from urea	Percent N applied from organic sources						Total N applied (kg ha^{-1})
		Cattle	Poultry	Sheep	Onion	Wheat	Berseem	
T_1	0	0	0	0	0	0	0	0
T_2	100	0	0	0	0	0	0	120
T_3	75	25	0	0	0	0	0	120
T_4	75	0	25	0	0	0	0	120
T_5	75	0	0	25	0	0	0	120
T_6	75	0	0	0	25	0	0	120
T_7	75	0	0	0	0	25	0	120
T_8	75	0	0	0	0	0	25	120
T_9	50	50	0	0	0	0	0	120
T_{10}	50	0	50	0	0	0	0	120
T_{11}	50	0	0	50	0	0	0	120
T_{12}	50	0	0	0	50	0	0	120
T_{13}	50	0	0	0	0	50	0	120
T_{14}	50	0	0	0	0	0	50	120
T_{15}	25	75	0	0	0	0	0	120
T_{16}	25	0	75	0	0	0	0	120

T_{17}	25	0	0	75	0	0	0	120
T_{18}	25	0	0	0	75	0	0	120
T_{19}	25	0	0	0	0	75	0	120
T_{20}	25	0	0	0	0	0	75	120
T_{21}	0	100	0	0	0	0	0	120
T_{22}	0	0	100	0	0	0	0	120
T_{23}	0	0	0	100	0	0	0	120
T_{24}	0	0	0	0	100	0	0	120
T_{25}	0	0	0	0	0	100	0	120
T_{26}	0	0	0	0	0	0	100	120

Table 1: *The 26 treatments combination while using various sources and ratios of organic and inorganic N-fertilizers.*

N Source	2011	2012	Mean
Cattle Manure (CM)	38	41	39
Poultry Manure (PM)	40	44	42
Sheep Manure (SM)	39	42	41
Onion Residues (OR)	36	40	38
Wheat Residues (WR)	33	37	35
Berseem Residues (BR)	37	42	40
Level of Significance	ns	ns	**
75U : 25OS	47	47	47
50U : 50OS	45	49	47
25U : 75OS	44	48	46
Level of Significance	**	ns	ns
Urea + Organic sources			
Urea + Cattle Manure	46	48	47
Urea + Poultry Manure	48	49	48
Urea + Sheep Manure	47	49	48
Urea + Onion Residues	44	48	46
Urea + Wheat Residues	43	44	44
Urea + Berseem Residues	46	49	47
Level of Significance	**	*	ns
Planned mean comparison			
Control	38	34	36b
Rest	45	47	46a
Urea	52	52	52a
Mixture	45	46	46a
Pure OS	37	41	39a
Mixture	45	48	47a
Urea	52	52	52a

Pure OS	37	41	39b
Animal Manure (AM)	45	47	46a
Crop Residues	42	45	44a
Urea	52	52	52a
Pure OS + Mix	43	46	45a
Interactions	Significance	Interactions	Significance
Y x OS	ns	Y x U vs. Mix	ns
Y x ratios	*	Y x OS vs. Mix	ns
Y x mixtures	ns	Y x AM vs. CR	ns
Y x control vs. rest	**	Y x U vs. OS & Mix	ns
Y x urea vs. OS	**		

Where: **, ** indicates that data is significant at 5 and 1% level of probability, respectively. The word ns stand for the non-significant data at 5% level of probability. Means followed by different letters in the same category are significantly different at 5% level of probability.*

Table 2: *Plant height (cm) of rice hybrid "Pukhraj" at tillering as affected by source and ratios of organic (crop residues vs. animal manures) and inorganic (urea) N-fertilizers.*

N Source	2011	2012	Mean
Cattle Manure (CA)	78	86	82
Poultry Manure (PM)	81	88	85
Sheep Manure (SM)	78	82	80
Onion Residues (OR)	73	79	76
Wheat Residues (WR)	67	75	71
Berseem Residues (BR)	74	84	79
Level of Significance	*	ns	**
75U : 25OS	96	93	94
50U : 50OS	90	99	95
25U : 75OS	88	96	92
Level of Significance	***	*	ns
Urea + Organic sources			
Urea + Cattle Manure	92	98	95
Urea + Poultry Manure	95	101	98
Urea + Sheep Manure	92	96	94
Urea + Onion Residues	90	95	92
Urea + Wheat Residues	87	91	89
Urea + Berseem Residues	91	96	93
Level of Significance	*	ns	ns
Planned mean comparison			
Control	75	69	72b
Rest	89	94	92a

Urea	103	105	104a
Mixture	91	93	92a
Pure OS	75	82	79a
Mixture	91	96	94a
Urea	103	105	104a
Pure OS	75	82	79b
Animal Manure	90	95	92a
Crop Residues	85	90	87a
Urea	103	105	104a
Pure OS + Mix	91	96	94a
Interactions	Significance	Interactions	Significance
Y x OS	ns	Y x U vs. Mix	ns
Y x ratios	***	Y x OS vs. Mix	ns
Y x mixtures	ns	Y x AM vs. CR	ns
Y x control vs. rest	*	Y x U vs. OS & Mix	ns
Y x urea vs. OS	**		

Where: **, ** indicates that data is significant at 5 and 1% level of probability, respectively. The word ns stand for the non-significant data at 5% level of probability. Means followed by different letters in the same category are significantly different at 5% level of probability.*

Table 3: *Plant height (cm) of rice hybrid "Pukhraj" at flowering as affected by source and ratios of organic (crop residues vs. animal manures) and inorganic (urea) N-fertilizers.*

N Source	2011	2012	Mean
Cattle Manure (CM)	85	93	89
Poultry Manure (PM)	88	95	92
Sheep Manure (SM)	85	89	87
Onion Residues (OR)	80	86	83
Wheat Residues (WR)	74	80	77
Berseem Residues (BR)	82	91	86
Level of Significance	*	ns	**
75U : 25OS	107	104	105
50U : 50OS	101	107	104
25U : 75OS	98	106	102
Level of Significance	***	ns	ns
Urea + Organic sources			
Urea + Cattle Manure	103	107	105
Urea + Poultry Manure	106	110	108
Urea + Sheep Manure	103	106	104
Urea + Onion Residues	100	105	103
Urea + Wheat Residues	97	101	99

Urea + Berseem Residues	102	105	104
Level of Significance	*	ns	ns
Planned mean comparison			
Control	79	73	76b
Rest	98	103	101a
Urea	108	111	110a
Mixture	102	106	104a
Pure OS	82	89	86a
Mixture	102	106	104a
Urea	108	111	110a
Pure OS	82	89	86b
Animal Manure	99	104	102a
Crop Residues	94	99	97a
Urea	108	111	110a
Pure OS + Mix	97	102	99a
Interactions	Significance	Interactions	Significance
Y x OS	ns	Y x U vs. Mix	ns
Y x ratios	***	Y x OS vs. Mix	ns
Y x mixtures	ns	Y x AM vs. CR	ns
Y x control vs. rest	*	Y x U vs. OS & Mix	ns
Y x urea vs. OS	**		

Where: **, ** indicates that data is significant at 5 and 1% level of probability, respectively. The word ns stand for the non-significant data at 5% level of probability. Means followed by different letters in the same category are significantly different at 5% level of probability.*

Table 4: *Plant height (cm) of rice hybrid "Pukhraj" at physiological maturity as affected by source and ratios of organic (crop residues vs. animal manures) and inorganic (urea) N-fertilizers.*

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